Adsorption Characteristics of Bentonites for Chromium in Waste water

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Summary: This investigation is based on the removal of chromium (III) from waste water by batch adsorption process using natural bentonites as an adsorbent collected from various locations of Pakistan. Bentonite contains montmorillonite, which has the quality to adsorb inorganic and organic materials. The quantities of chromium (III) ions in water before and after the treatment of its standard solution (8 ppm) with different samples of bentonite were determined by atomic absorption spectroscopic method. The adsorption of chromium (III) was studied at room temperature *i.e.* 30 °C, pH 7 and 200 mesh particle size using 50 mL of metal solutions and 25 gram of bentonite samples for one hour. The percentage adsorption for chromium on bentonite samples was also determined. It was found that bentonite is suitable adsorbent for removal of chromium. This method is preferable over other methods as it is simple with no complex apparatus involved.

Introduction

Waste water treatment is considered to be an integral part of any industrial process design. The environment protection agencies in different countries including Pakistan place significant emphasis on removal of toxic substances from industrial wastes prior to their discharge from the treatment plants into water bodies [1]. With the rapid growth of tannery industry, the level of chromium in the effluents is rising sharply and posting a constant threat to the environment [2] affecting aquatic life and polluting ground water. Chromium compounds are toxic and can cause harmful and irreversible damage to health by single, repeated, or prolonged absorption. Applications [3] of modified clays have also been reported for the removal of heavy metals from Waste water. Khan *et al.* [4] studied the sorption of Cr^{3+}, $Cr^{4+}$and Ag^{1+} from aqueous solutions on bentonite by a batch technique. Their results showed that sorption is less favored at high temperature for Cr^{3+} and Ag^{1+} while for Cr^{4+}, sorption is favored at high temperature. Al-Duri *et al.* [5] introduced the adsorption process in water purification, applications of adsorption, adsorption as a separation process, adsorption mechanism and adsorber design. Shujing *et al.* [6] provided a review with 36 references on the research progress in the application of bentonite in waste water treatment. Mehmood [7] studied the adsorption of chromium on bentonite and its application for the removal of chromium from tanneries effluent. Maximum adsorption of chromium was observed at pH 4, 30 μ particle size and at 40 °C when treated for 4 hours. Abollino *et al.* [8] reported that clays (especially montmorillonite and bentonite) are widely used as barriers in landfills to prevent contamination of subsoil and groundwater by leachates containing heavy metals. Andrade *et al.* [9] evaluated the use of special clays for heavy metal removal from waste water. The heavy metal contents in solution were analyzed before and after the water circulation through the clay beds. The sepiolite and the magnesic bentonite were effective in reducing the heavy metal concentration of the industrial waste water samples.

The main object of the present work is to remove the chromium (III) from water by batch adsorption process using bentonites as an adsorbent collected from various areas namely Khushab, Quetta, Attock, Azad Kashmir, Peshawar and Jehlum cities of Pakistan.

Results and Discussion

In present investigation, the adsorption behavior of various samples of bentonites was studied for chromium (III) in waste water. The absorbances of chromium standards were noted by atomic absorption spectrophotometer (Table-1).

The calibration curve was plotted as the concentration *vs* absorbances of chromium standards. (Fig. 1)

Table-1: Absorbance of chromium standards.

Sr. No.	Concentration (ppm)	Absorbance
1	0.0	0.00
2	2.0	0.053
3	4.0	0.086
4	6.0	0.135
5	8.0	0.185

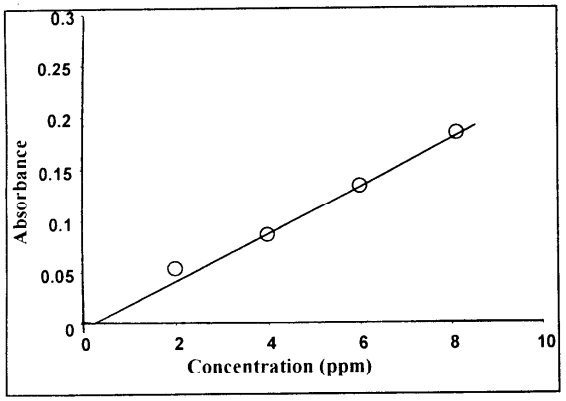

Fig. 1: Calibration curve for Cr^{3+}.

The adsorption of chromium (III) with concentration of 8 ppm solution was studied on bentonite samples for one hour. The concentration of metal ions after each treatment with bentonite samples was noted from the calibration curve (Tables-2 and 3).

Table-2: Absorbance of filtrates after adsorption of Cr^{3+} solutions with 25 gram bentonite.

Sr. No.	Solutions from bentonite samples	Absorbance
1	Blank (dist. Water)	0.0
2	Khushab sample	0.005
3	Jehlum sample	0.002
4	Attock sample	0.009
5	Quetta sample	0.003
6	Azad Kashmir sample	0.001
7	Peshawar sample	0.004

Table-3: Absorbance of filtrates after adsorption of Cr^{3+} solutions with 1 gram bentonite.

Sr. No.	Solutions from bentonite samples	Absorbance
1	Blank (dist. Water)	0.0
2	Khushab sample	0.061
3	Jehlum sample	0.020
4	Attock sample	0.012
5	Quetta sample	0.012
6	Azad Kashmir sample	0.020
7	Peshawar sample	0.015

It was observed that all the chromium (III) contents in 8 ppm solution were adsorbed on all the bentonite samples. The percentage adsorption was 100 % when the experiment was undertaken with a constant amount (25 gram) of bentonite.

Such experiment was also carried out using minimum quantity of bentonite samples, *i.e.* 1 gram. The adsorption of chromium in 8 ppm solution was studied with these samples by keeping time for adsorption as 1 hr.

The percentage adsorption was calculated for Cr^{3+} by inserting the values of absorbance in calibration curve. It was observed that when 1 gram quantity of bentonite were used, the percentage adsorption of chromium on Khushab bentonite was 63.75 % , Jehlum 86.25 % , Attock 90 % , Quetta 90 % , Azad Kashmir 86.25 % and Peshawar 88.75 % (as shown in Fig. 2).

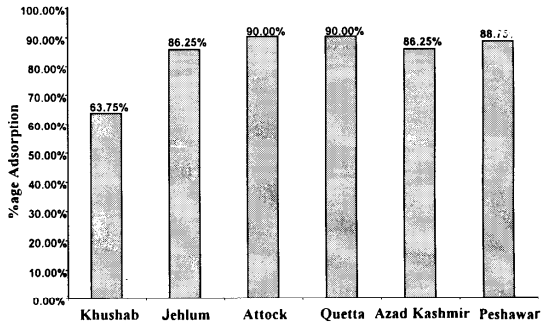

Fig. 2: Level of chromium adsorption on 1 gm. samples of bentonite.

Experimental

Preparation of Chromium Standards

Stock chromium solution was prepared by dissolving 7.69 gram of chromium nitrate in de-ionized water and volume made upto 1000 mL. Standard solutions of different concentrations were prepared from the stock solution.

Samples

Bentonite samples were collected from Khushab, Attock, Jehlum, Azad Kashmir, Quetta and Peshawar. All bentonite samples were oven dried at 100 °C for 2 hours. These samples were crushed to fine powder. Then fine powder was passed through a 200 mesh sieve.

Contamination Control

All glass wares were washed carefully and rinsed with distilled water and kept in dust free atmosphere.

All the reagents used were of analytical grade. Experiment was carried out at room temperature *i.e.* 30 °C, pH 7 and particle size of all samples used was 200 mesh. 25 gram each of bentonite sample was taken in separate beakers. 50 mL of solution containing 8 ppm chromium (III) was added to it for adsorption and stirred. Then it was left for one hour in order to maintain the equilibrium. After treatment with bentonite samples these solutions were filtered carefully. The filtrate obtained was analyzed for Cr (III) concentration using atomic absorption spectrometer.

The percentage of chromium (III) after treatment with bentonites was noted by inserting the values of absorbance of each solution in calibration curve.

Conclusion

It is concluded from these investigations that bentonite is a good adsorbent and can be used for the maximum removal of chromium (III) ions from water.

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